The Use of Atmospheric Reanalyses to Study Earth's Crust Deformations

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What?

Variations of air mass column causes Earths' crust deformation up to 40 mm in vertical direction and 12 mm in horizontal. Predicted by G. Darwin (1882), detected in 90s (T. van Dam & T. Herring 1994), used in routine data reduction since 2002 (L. Petrov & J.-P. Boy). Nowadays, accuracy of space geodesy techniques, such as GPS and other methods, is high enough not only to detect such deformations, but it allows to discriminate competing models.

Displacements are computed by convolving the surface pressure anomalies with appropriate Green's functions that describe the Earth's response to a unit mass loading:

$$u_r(\vec{r},t) = \iint \Delta P(\vec{r}',t)\,\mathbf{G}_{\mathrm{R}}(\psi)\cos\phi' d\lambda' d\phi'$$

$$\vec{u}_h(\vec{r},t) = \iint \vec{q}(\vec{r},\vec{r}')\,\Delta P(\vec{r}',t)\,\mathbf{G}_{\mathrm{H}}(\psi)\cos\phi' d\lambda' d\phi'$$

Why it is needed?

Variations in site positions caused by the atmospheric pressure loading are a source of *noise* that limits our ability to study tectonic and global change signals. Therefore, there is a necessity to model the atmospheric pressure loading with accuracy better than 0.1 mm or 0.5%.

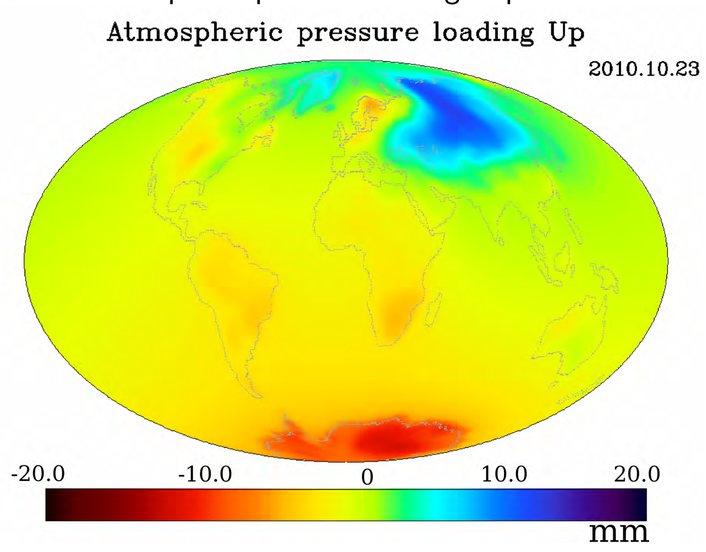
The errors in computation of the atmospheric pressure loading are caused by a) errors in Greens' functions that are due to our poor knowledge of Earth's interior and b) errors in the global field of the surface pressure anomalies.

Why reanalysis?

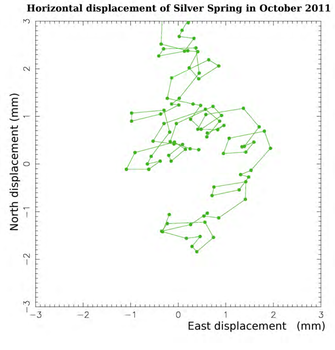
Time series of loading displacements should not have jumps and discontinuities due to changes in the model. Such discontinuities would mimic tectonic motion and cause biases in estimates of global trends.

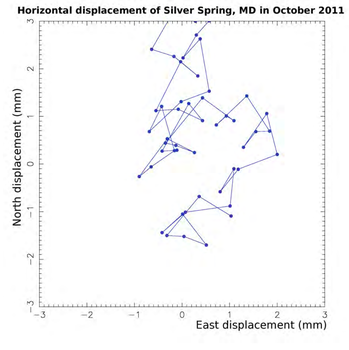
How does it look like?

Global atmospheric pressure loading displacement field

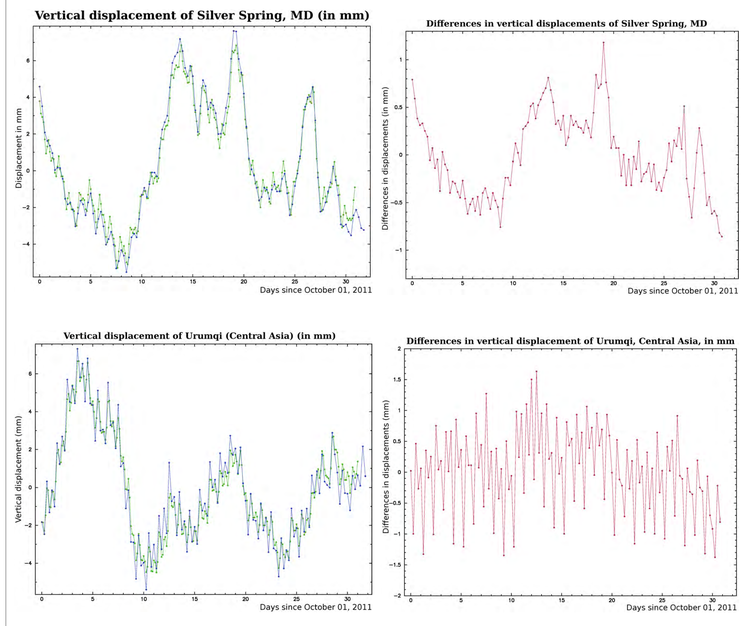


Horizontal displacement computed with **MERRA** $(0.67^\circ\times0.5^\circ\times3^h)$ resolution (left) and with **NCEP Reanalysis–1996** $(2.5^\circ\times2.5^\circ\times6^h)$ resolution (right).





Effect of different resolution on results of computations of displacements caused by the atmospheric pressure loading.
Green curve: MERRA $(0.66^\circ\times0.5^\circ\times3^h)$ resolution.
Blue curve: NCEP Reanalysis–1996 $(2.5^\circ\times2.5^\circ\times6^h)$
Right: **the differences** in site displacements.



What is needed?

- better time resolution of global numerical whether models;
- homogeneity of the surface pressure field over decades;
- low latency in the global pressure field data products.